Technology Demonstration Fact Sheet

Two-Dimensional Linear Motion System

SUMMARY

Two-dimensional linear motion systems can be used to semi-robotically operate tools or instruments on surfaces. The Pentek, Inc. (Coraopolis, PA) 2-D Wall Walkeρ™ was demonstrated at the Hanford Site C Reactor complex. Such systems are suitable for high, flat (or slightly curved) surfaces. For decommissioning and decontamination (D&D) projects, they can be used for radiological characterization surveys and follow-up decontamination, and for final or release radiological surveys. The demonstration was done with a free-release survey of outside walls at the reactor front face work area and also included an assessment of the system payload weight capacity for deployment of decontamination tools.

The baseline method is to place personnel in proximity to the wall using scaffolding or manlifts. (Both the baseline and the innovative methods use the same radiation detector, with its automatic remote mapping of radiation levels.)

Comparisons and results of the improved technology versus the baseline were as follows:

- More time for setup/takedown, but faster scanning (with the baseline, the technician must pause each time the lift is repositioned).
- The larger the survey area, the more time saving is achieved with the improved method.
- The improved system could be used to operate tools remotely, as well as survey instruments, resulting in improved ALARA.
- Can automatically return to an indicated hot spot with a tool or instrument rapidly and reasonably accurately for decontamination action or a resurvey.

IMPROVED TECHNOLOGY DESCRIPTION

Two high-strength steel cables are managed by servo-motor-driven pulleys that are attached or suspended to the upper left and right sides of the wall. Both cables are joined together near a single point where the end effector is attached. The length of each cable is precisely controlled by a computer that directs the motion of the pulleys. With the software employed, the lengths of each of the two cables are known from computer monitoring of the cable lengths paid out or retrieved, and the position is displayed as X-Y coordinates. The operator arbitrarily chooses the location of the X-Y origin - typically the lower left corner. Software was used to correct for cable stretch in computing X-Y positions. The wall span and height that could be reached by the end effector is limited only by the length of cable furnished.

The motor-driven pulleys can be attached to the wall temporarily with magnetic force for steel walls, or with anchors or vacuum force for concrete walls. For locations with no ceiling in the way, the pulleys can be attached to standoffs above the wall, thereby allowing the end effector to reach the full height of the wall. Otherwise, up to 6 vertical feet at the top of the wall cannot be reached. Similarly, if there are no sidewall restrictions, the standoffs can be positioned to allow reaching the full wall width instead of missing 1 to 2 feet at the sides. The pulley assemblies weigh 50 pounds each.

The operator can command the system to traverse any two-dimensional path at constant speeds up to 60 feet per minute. A device suitable for holding the tool or instrument and attached to each cable with a yoke and clevis must be obtained from the vendor or fabricated especially for the intended service. Pentek has standard tool holders with shrouds available for a variety of decontamination/characterization devices. The shroud is held against the wall with either vacuum force or with out-rigged weights and is fitted with casters for smooth traversing. For example, an aggressive concrete decontamination tool can be held in a shroud with a vacuum hose that is connected at ground level to a filtration unit. If the wall has protrusions (e.g., piping or conduit runs), a tether attached to the shroud can be manually manipulated at ground level to temporarily pull an end effector away from the wall. Present Pentek system designs can operate with shroud/tool combinations weighing up to 2000 pounds. Potential applications of the system include radiation surveys, marking designated areas, decontamination, and painting.

The controller can be used by the operator either to pre-program the pathways or manually guide the traverses. The motions can readily be rehearsed prior to applying the tool.

BASELINE TECHNOLOGY DESCRIPTION

An aerial lift was used to provide technician access to a 47-ft high outside concrete wall for a release survey. (The same access method is used routinely for high inside walls). The area surveyed was 14 ft wide by 27 ft high, near the top of the wall. The target scanning speed for the 6-inch high radiation detector was 4 inches/sec. with a 2-inch overlap for each horizontal scan that was performed. The maximum production rate with these conditions is 6.7 sq ft/min. The actual production rate was 3.1 sq ft/min, allowing for overlaps that exceeded 2 inches and time lost due to intermittent repositioning of the aerial lift and 10% break time to rest fatigued arms. The recording system selected for this survey included automatic mapping of location and radiation levels, so no time was lost for manual recording of data. Essentially, all of the wall desired to be surveyed (378 sq ft) was surveyed with this method, and there was no substantial setup time or takedown time required.

DEMONSTRATION DESCRIPTION

The same radiation detector and automatic mapping system used in the baseline demonstration was employed for the demonstration of the linear motion system. Although the linear motion computer could be adapted to perform mapping, it was only used here for automatically positioning the radiation detector and setting the scanning speed. Outside concrete walls at the same building complex as at the baseline demonstration, and of the same height, were surveyed. The Wall Walker motorized pulleys were mounted near upper wall corners as would be done for deployment on inside walls with ceiling and corner interferences. With this configuration, six feet of wall at the top and up to three feet of wall at each side were not accessed with the Wall Walker. These missed areas can be surveyed with the baseline access method. In this case, the aerial lift used to aid in mounting the pulleys would be the choice for accessing the top and sides of the walls needing surveying. The pulley assemblies were mounted by bolting to concrete anchors after a manual radiation survey was performed at each mounting area.

Enough cable length was furnished for this demonstration to access walls up to 50 ft wide by 50 ft high. The radiation detector was mounted in a shroud that was counter weighted to cause pressure against the wall and fitted with casters set to provide 1/4-inch standoff from the wall. (The shroud also had a vacuum hose fitting in the event vacuum force and/or HEPA filtration were desired.) The cables were threaded through the pulleys by accessing with the aerial lift and attached to the shroud at ground level. A rope attached to the shroud was used to manually pull the assembly over and around protrusions.

Over 2000 sq ft of wall areas were surveyed. A 60-ft wide wall was surveyed in two sections, each almost 30 ft wide. A 27.5-ft wide section of another wall was surveyed. A demonstration of payload capability was conducted at a third wall. The time durations required for unpacking, setup, surveying, takedown, and packing were recorded. After the initial setup, the duration for setup and takedown subsequentially averaged 45 minutes. The survey production rate averaged 6 sq ft/min, with the horizontal scanning speed set at 4 inches/sec and with 2-inch vertical overlap as in the baseline survey. The theoretical maximum production rate of 6.7 sq ft/min was not attained because the Wall Walker system has a slight pause prior to each vertical move. Based on the measured durations, the setup/takedown plus survey time would equal the baseline survey duration with the Wall Walker deployed over ~260 sq ft. Approximately 5% of the wall areas covered were not scanned because of interfering protrusions.

The demonstration also showed that the positioning accuracy was within 1-2%, repeatability was within 1 in., and speed accuracy was within 7%. The cable and pulley system furnished was rated at 350 pounds payload, and was successfully demonstrated with 300 pounds added. Onsite personnel were instructed by a vendor technician for part of the work. A Radiological Control Technician and D&D workers quickly learned the mechanical assembly and touch-screen control techniques.

DETAILS OF BENEFITS

- More accurate and consistent scanning conditions for surveys
- Improved production rates for large walls
- Payload capacity at least 300 lb
- Accurately positions instruments and tools repeatedly
- Remote operation provides improved ALARA
- For radiation surveys, the controller software could be adapted to provide maps showing the location of measured radiation levels.

SUCCESS CRITERIA

- Accurate positioning and speed control
- Good repeatability
- Adequate payload capacity
- Maneuverability around/over wall protrusions
- Capable of holding a tool or instrument against walls or at a preset standoff distance
- Simple to deploy, requiring minimal skill levels
- Improved ALARA practice

SCHEDULE

The system was unpacked and set up initially on September 22- 23, 1997. Delays were encountered in modifying the shroud attachments, and preliminary test runs were conducted. Wall surveys, accuracy checks and speed checks were done on September 24-26. The payload assessment and packing were done on September 26.

FUTURE APPLICABILITY

Two-dimensional linear motion systems, such as the one demonstrated, can best be used for walls over 16 ft high that have large areas free of protrusions. Potential applications include pre-job characterization surveys, marking designated wall areas, applying paint and fixatives, deploying decontamination tools, and performing release surveys.

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